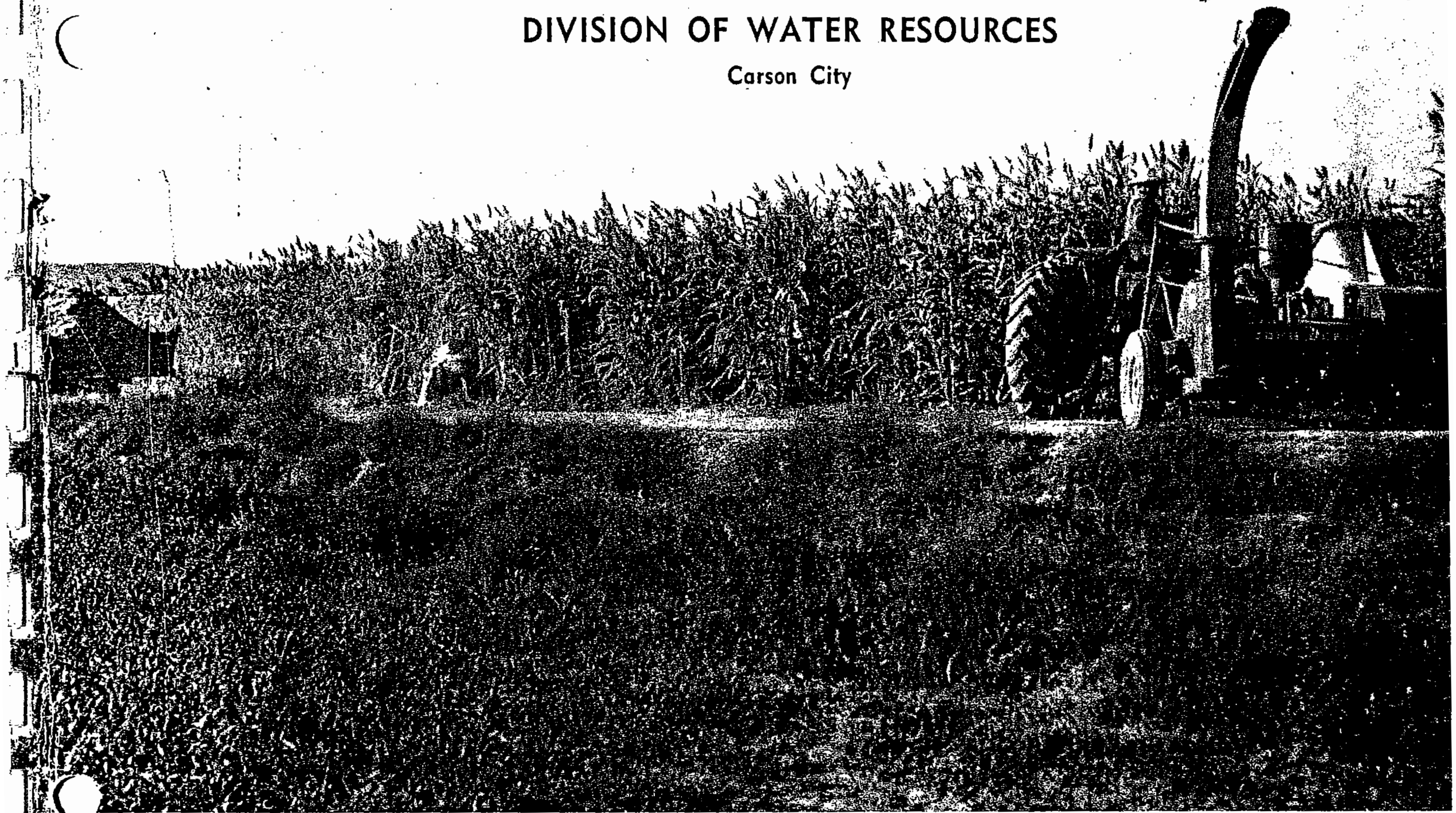
STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
Carson City



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WATER RESOURCES–RECONNAISSANCE SERIES
REPORT 50

WATER–RESOURCES APPRAISAL OF THE LOWER MOAPA–LAKE MEAD AREA, CLARK COUNTY, NEVADA

By
F. Eugene Rush

Prepared cooperatively by the
Geological Survey, U.S. Department of the Interior

DECEMBER 1968

WATER RESOURCES - RECONNAISSANCE SERIES

REPORT 50

WATER-RESOURCES APPRAISAL OF THE LOWER MOAPA-LAKE MEAD AREA, CLARK COUNTY, NEVADA

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CONTENTS

TABLES

ILLUSTRATIONS

irrigation, 13,000 acre-feet, outflow of the Muddy River, 10,000 acre-feet, and evapotranspiration of ground water by nonbeneficial phreatophytes, 11,000 acre-feet.

Ground-water quality reflects the abundance of soluble minerals in the area; most ground-water samples had high concentrations of dissolved solids. The flow in Las Vegas Wash, mostly water used in Las Vegas Valley, was high in dissolved solids. Muddy River water, though having a high salinity hazard, has been proved chemically acceptable for irrigation under good management and soil conditions.

System yield of the combined California Wash-Lower Moapa Valley area is estimated to be 40,000 acre-feet, of which 22,000 acre-feet was consumed in 1967. For the Black Mountains Area, the estimated system yield is 7,000 acre-feet. Estimated perennial yields of the remaining areas are: Hidden Valley, 200 acre-feet, Garnet Valley, 400 acre-feet, Gold Butte Area, 500 acre-feet, and Greasewood Basin, 300 acre-feet.

Water use in 1967 in all areas was less than the estimated yields. However, development of water in Las Vegas Wash may be limited because of its poor quality. In areas adjoining Lake Mead, supplies can be developed from the lake, subject to legal limitations.

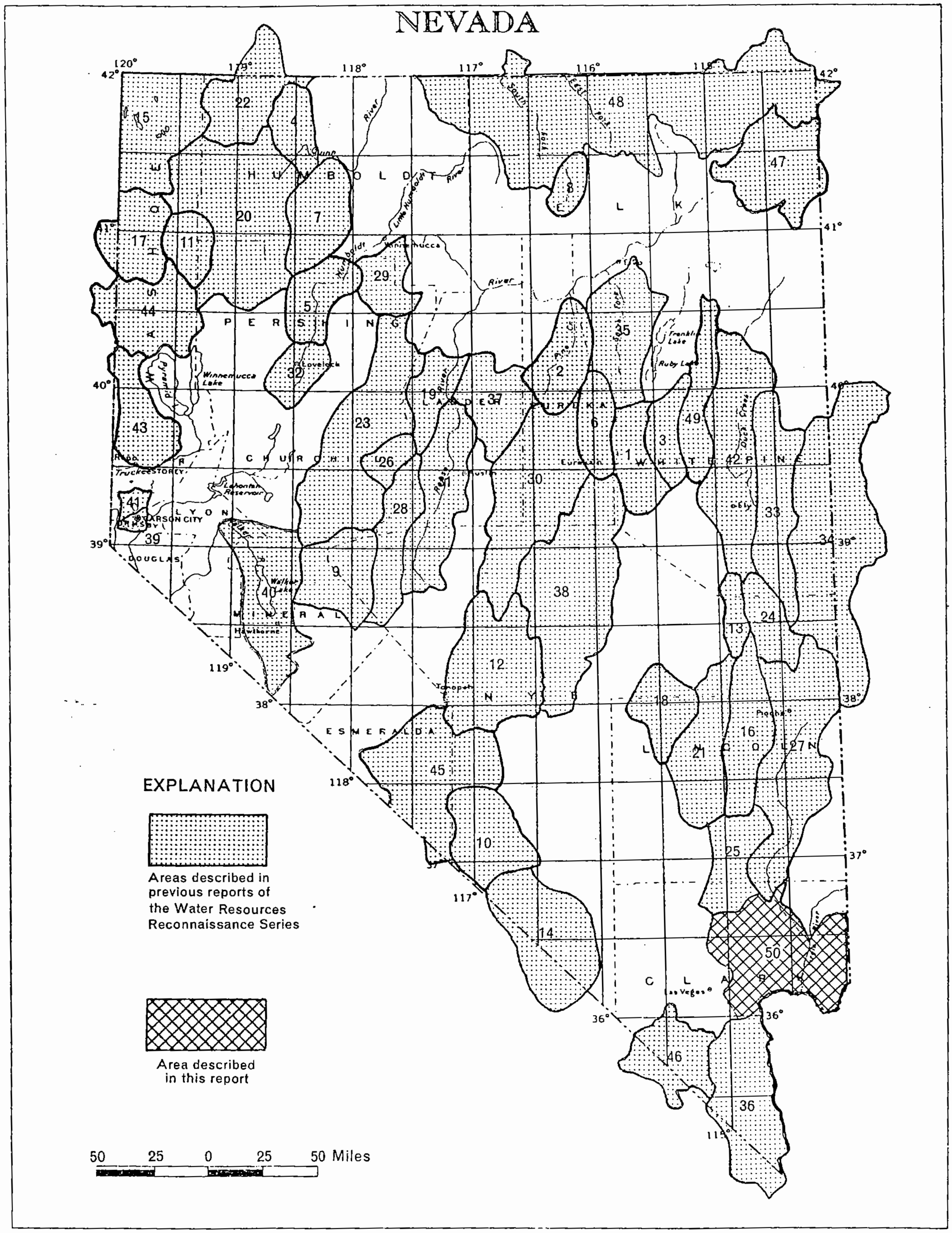

Figure 1.—Index map showing areas in Nevada described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

Soils of the flood plain of the Muddy River were mapped by Young and Carpenter (1928) and more recently by the Bureau of Reclamation (1962).

Most of the project area has been mapped as part of the 15-minute topographic quadrangle series (scale about 1 inch to the mile) of the Topographic Division, U.S. Geological Survey. The maps include Arrow Canyon, Dry Lake, Gass Peak, Gold Butte, Hayfork Peak, Henderson, Hoover Dam, Iceberg Canyon, Las Vegas, Moapa, Muddy Peak, Overton, Overton Beach, Virgin Basin, and Virgin Peak.

Acknowledgments

Information was provided by many residents, companies, and agencies and was greatly appreciated: Jim Long, Bureau of Indian Affairs; Howard Pulsipher, Hidden Valley Ranch; Bill Loftis, National Park Service; Jay Whipple, Moapa Valley Water Company; Carl Marshall, Muddy Valley Irrigation Company; C. E. McClaren, Bureau of Reclamation; Jim Zornes, Nevada Power Company; Durrell Evans, Soil Conservation Service; C. C. Larkin, Union Pacific Railroad Company; Simplot Silica Products, Incorporated; Pabco Gypsum; and many land owners and water users of the area.

Table 1.--General topographic features

Hydrographic area	Area (square miles)				Adjoining mountains (altitude in feet)	Valley floor (altitude in feet)	Average relief (feet)	Consolidated rock-alluvium contact (altitude in feet)
	Consolidated rock	Alluvium	Lake[1] Mead	Total				
Hidden Valley	38	35	0	73 (46,720 Acres)	3,000-7,000	2,650-2,720	4,000	2,700-4,000
Garnet Valley	52	115	0	167 (106,960 Acres)	3,000-7,000	1,970-2,000	5,000	2,100-4,200
California Wash area	85	240	0	325	3,000-5,000	1,500-2,200	3,000	1,600-3,800
Lower Moapa Valley	53	183	0	236	3,000-6,000	1,250-1,400	4,000	1,600-4,000
Black Mountains Area	230	307	90	627	3,000-5,000	a 1,221	3,000	1,200-3,400
Gold Butte Area	233	240	55	528	2,000-8,000	a 1,221	6,000	1,200-4,000
Greasewood Basin	70	43	1	114	3,000-8,000	a 1,221	6,000	2,200-4,100

a. No valley floor present; number is altitude of lowest alluvial area at maximum Lake Mead level.

1. Area of lake at maximum stage within Nevada and adjacent to valley or area shown.

Younger alluvium, in contrast to older alluvium, generally is unconsolidated, undissected, moderately well sorted, and undeformed. It is Quaternary in age and is composed of sand, silt, and clay deposited by the principal streams on the valley floors as shown on plate 1. Younger alluvium also underlies playa; the deposits are of late Pleistocene and Holocene (Recent) age. The coarse-grained material of the younger alluvium probably is more porous and more permeable than older alluvium.

Faults have been mapped by Longwell and others (1965) and by the writer from aerial photos. Only those that cut older alluvium are shown on plate 1.

Water levels in Lower Moapa Valley, along the Muddy River in California Wash area, along the shores of Lake Mead, and along the banks of Las Vegas Wash probably are higher than they were under native conditions, because of the new ground-water base level created by Lake Mead. Carpenter (1915) lists two wells in an area of Lower Moapa Valley now flooded by Lake Mead. A dug well, 16/68-33, had a depth to water of 20.4 feet, and a drilled well 805 feet deep at St. Thomas (probably in 17/68-10d) first struck water at 30 feet but was cased out with a final depth to water of 284 feet (neither well is shown on pl. 1). These measurements were made in 1912. Today, on the flood plain of the Muddy River in the report area, no depths to water probably are as great as 20 feet.

At St. Thomas, the apparent loss of head with depth would imply that water was moving downward in that area and then laterally, probably to the Colorado River. The deep-well site was probably at an altitude of about 1,150 feet; the water level would have been about at an altitude of 870 feet. This is much lower than the Virgin River, about 3 miles southeast, that was flowing on a flood plain at altitude 1,100 feet. In fact, the Virgin River did not reach an altitude of 870 feet until 8 miles north of its mouth or about 18 miles downstream from St. Thomas. The circulation system that causes the loss of head at St. Thomas may also have reduced the flow of the Virgin River in the same area, the water reappearing again at the surface along the channel of the Colorado River, the regions former discharge level. A spring at the Syphus Ranch (about 19/68-16), as shown by Carpenter, may have been a discharge point for the system, but this writer's estimated altitude of the spring (about 920 feet) is too high to discharge the system related to the St. Thomas area. The water quality of this spring and of the deep well at St. Thomas were similar, as listed by Carpenter (1915, p. 30). Elsewhere in the report area, near native conditions prevail. Pumping of wells has had a negligible effect throughout the area.

The rocks in the area contain mostly calcium and magnesium carbonates and silicate minerals. In addition, Longwell and others (1965, Appendix A and B) list many metallic and nonmetallic mineral deposits in the area, including: Metallic sulfides in the Gold Butte Area, borate deposits in the Black Mountains Area, gypsum beds, the most extensive of which are in the Black Mountains Area, and salt (halite) deposits, now inundated, along the Overton Arm of Lake Mead. These minerals, therefore, provide a ready source for most of the dissolved constituents in the ground water of the area.

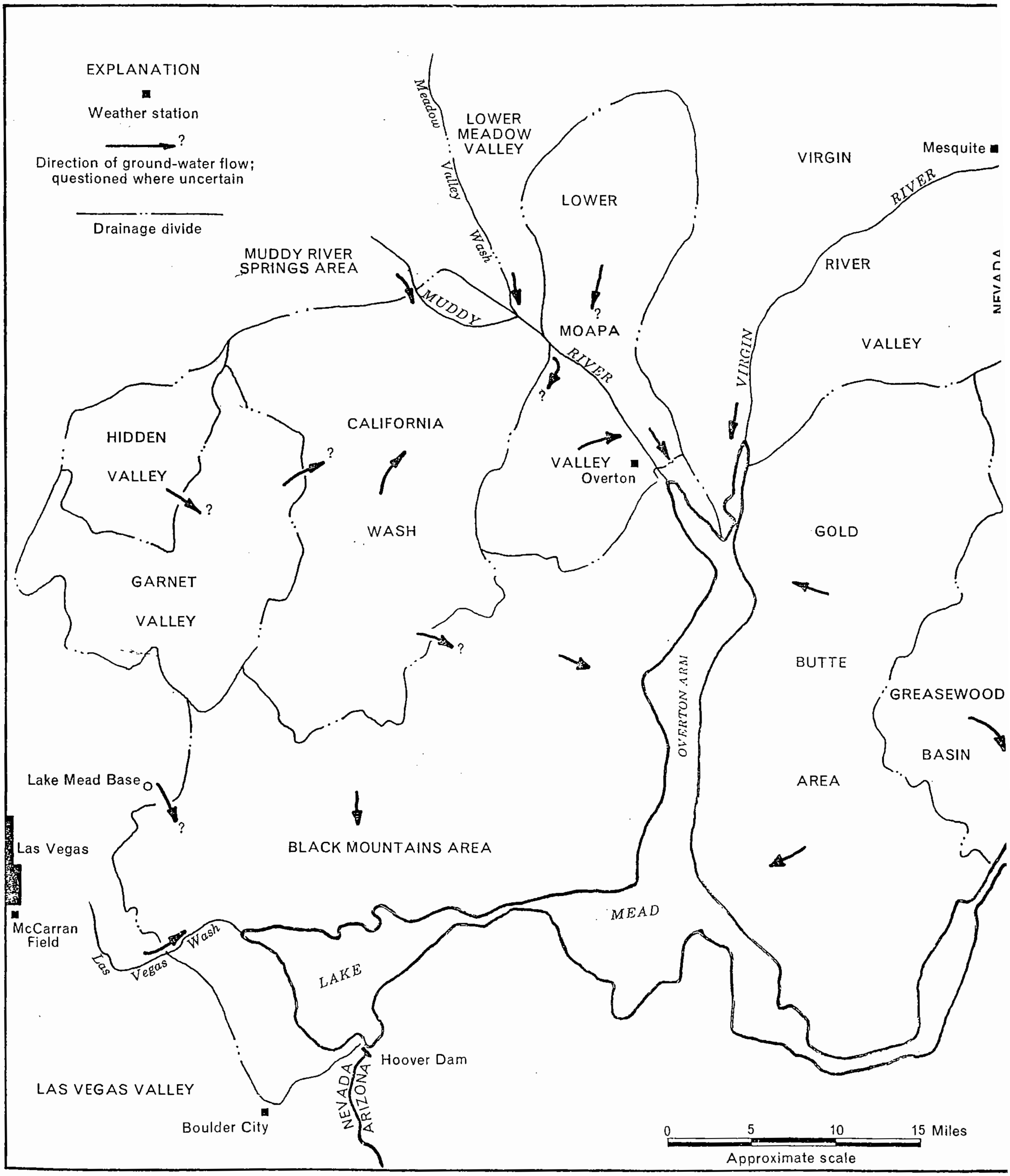

Figure 2.—Location of nearby weather stations and direction of ground-water flow

INFLOW TO THE VALLEY-FILL RESERVOIRS

Inflow to the valley-fill reservoirs is estimated by reconnaissance techniques developed by the Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The components of inflow to the valley-fill reservoirs include precipitation, surface-water runoff, subsurface inflow through alluvium and carbonate rocks, and importation of water (table 14). Lake Mead is not included in the hydraulic budget of the area.

Precipitation

The precipitation pattern in Nevada is related principally to the topography; the weather stations at higher altitudes generally receive more precipitation than those at lower altitudes (Hardman, 1965). However, this relation may be considerably modified by local conditions. The valley floors of the report area probably receive an average of only about 3 to 5 inches of precipitation per year, whereas the highest mountain areas may have an average annual precipitation of 12 inches or more. Figure 3 demonstrates the increase in precipitation with altitude.

Nearby weather stations at Mesquite, Boulder City, Overton, and McCarran Field at Las Vegas are shown in figure 2. Five more remote stations have the following locations:

- Littlefield, Arizona, 10 miles northeast of Mesquite
- Carp, 30 miles north of Glendale
- Desert National Wildlife Range, 22 miles northwest of Las Vegas
- Mount Trumbull, 50 miles southeast of Mesquite
- Hidden Forest Camp, 32 miles north of Las Vegas

Using the data recorded at these nine stations, an altitude-precipitation relation, as shown by the dashed line in figure 3, was identified. This relation is used as a basis to compute estimated average annual precipitation and ground-water recharge in table 6.

On valley floors and aprons, where the average annual precipitation is small, little precipitation directly infiltrates into ground-water reservoirs. Most precipitation is evaporated before infiltration and some adds to soil moisture. However, intense precipitation during thunderstorms may supply infrequent recharge. Greater precipitation in the mountains provides most of the recharge and runoff.

Surface Water

By D. O. Moore

The dominant hydrologic feature of the area is Lake Mead. The lake was formed behind Hoover Dam, when the bypass gates were closed in 1935. With water level at the spillway, altitude 1,221 feet, the maximum depth of the reservoir would be 571 feet at the dam; the water-surface area would be 164,000 acres, and the reservoir capacity would be 29,680,000 acre-feet (Ames and others, 1960, p. 87-91). The weight of Lake Mead, about 40 billion tons at spillway level, has caused settlement of the general area, which by 1950 had reached a maximum of 7 inches (Raphael, 1954). This settlement is still continuing, but at decreasing rate; the total may eventually reach 10 inches.

Water from Lake Mead infiltrates into the adjoining rocks and sediments, causing a local rise in ground-water levels. Langbein (1960, p. 100-102) estimates that bank storage amounts to an average of about 12 percent more than Lake Mead capacity at any given stage.

The flood plain of the Muddy River is well watered because of irrigation by water from the Muddy River, a perennial stream. Las Vegas Wash, in the report area, is also perennial. The remaining parts of the report area have a few short perennial streams where they are springfed.

The Muddy River has been gaged at five different sites within the report area. Only one of these gages, Muddy River near Glendale, is still in operation. This gage is at Jackman Narrows (15/67-7ca, pl. 1) and has been operated from April through October 1910, July 1913 to February 1914, and from February 1950 to the present time. The location and period of record for the four discontinued gages on the Muddy River are as follows:

(1) Muddy River at railroad pumping plant (15/66-6d). Operated from 1904 to 1906 and 1914 to 1917.

(2) Muddy River above Moapa Indian Reservation (14/65-26c). This gage was operated from 1914 to 1918.

(3) Muddy River at Weiser Ranch (15/66-2bd). Operated from 1915 to 1917.

(4) Muddy River near Overton (15/67-21ab). Operated intermittently from 1913 to 1954.

Table 2.--Flow volume and duration for Las Vegas Wash at North Las Vegas, June 1962-September 1966

Period[1/]	Flow (acre-feet)	Duration (days)
1962		
August	8.7	11
1963		
April	1.2	2
May	1.4	2
June	14.0	2
September	181.	2
1965		
April	41.3	3
November	34.	1

1. No flow was recorded during unlisted months.

Table 4.--Mean annual discharge of the Muddy River and Las Vegas Wash

Year	Gaged discharge in acre-feet per year: Muddy River at 15/67-7ca	Gaged discharge in acre-feet per year: Las Vegas Wash at 21/63-30cd
1951	32,450	--
1952	39,600	--
1953	32,420	--
1954	32,140	--
1955	39,130	--
1956	31,500	--
1957	36,900	--
1958	33,450	15,200
1959	32,760	15,390
1960	42,070	14,490
1961	34,310	14,370
1962	31,150	12,230
1963	28,910	15,493
1964	29,270	16,028
1965	31,980	18,220
1966	30,810	19,170
1967	32,030	19,160
Average (rounded)	33,600	16,000

Table 5.--Estimated average annual surface-water flow between hydrographic areas

Outflow[1/] from	Inflow[2/] to	Stream	Location	Estimated average annual quantity (acre-feet)
Muddy River Springs Area	California Wash Area	Muddy River	White Narrows	a 33,000
Lower Meadow Valley	California Wash Area	Meadow Valley Wash	Glendale	b 400
Total (rounded)				33,000
California Wash Area	Lower Moapa Valley	Muddy River	Jackman Narrows	34,000
Las Vegas Valley	Black Mountains Area	Las Vegas Wash	At area boundary	12,000
Lower Moapa Valley	Lake Mead	Muddy River	At river mouth	c 10,000±
Black Mountains Area	Lake Mead[3/]	Las Vegas Wash and numerous washes	At shoreline	10,000
Gold Butte Area	Lake Mead[3/]	Numerous washes	do.	Small
Greasewood Basin	Arizona	do.	At State line	Small

1. No streamflow out of Hidden and Garnet Valleys.
2. No streamflow into Hidden and Garnet Valleys, Gold Butte Area, and Greasewood Basin.
3. For the purposes of this report, the shoreline of Lake Mead is taken as of an altitude of 1,200 feet. On February 1, 1968 the actual altitude of the lake surface was 1,123 feet (U.S. Bureau of Reclamation, oral commun.).
a. From Eakin (1964).
b. From Rush (1964).
c. Rough approximation based on few data gathered in 1967.

Table 7.--Estimated average annual subsurface flow between areas

Outflow from	Inflow to[1]	Location	Probable transmitting lithology	Estimated flow width (miles) (W)	Estimated hydraulic gradient (feet per mile) (I)	Estimated coefficient of transmissibility (gpd per foot) (T)	Estimated inflow[2] (acre-feet per year) (Q)
Garnet Valley	California Wash area	16/64, 17/64	Carbonate rock and alluvium	--	--	--	a 800
Muddy River Springs Area	California Wash area	White Narrows	Alluvium	--	--	--	Small[3]
Lower Meadow Valley	California Wash area	Glendale	Alluvium	--	--	--	b 7,000
	Total (rounded)						8,000
Las Vegas Valley	Black Mountains Area	20/63-7	Carbonate rock	c 1	c 15	c 1,000	d 20
		21/63-22	Alluvium	.5	e 80	10,000	<400
	Total (rounded)						400
Black Mountains Area	Lake Mead	At shore-line	Noncarbonate rock and alluvium	--	--	--	f <100
Gold Butte Area	Lake Mead	do.	do.	--	--	--	f 1,000
	Total (rounded)						1,000
Hidden Valley	Garnet Valley	16/63	Carbonate rock	--	--	--	f 400
California Wash area	Lower Moapa Valley	Jackman Narrows	Alluvium	--	--	--	Small
Lower Moapa Valley	Lake Mead	16/68	Alluvium	1	e 20	50,000	1,100
Greasewood Basin	Arizona	At State line	Alluvium	--	--	--	f 600

to start utilizing water from a third source, diversion of 2,000 acre-feet from the Muddy River at a site in the Muddy River Springs Area and imported to the generating station by pipeline. The power company reports that this diversion will be made only in the winter. At the generating station, the water is consumed principally by evaporation from cooling towers.

Moapa Valley Water Company reportedly imported about 520 acre-feet of water in 1967 from springs in the Muddy River Springs Area. The water was used for domestic, public supply, and stockwatering purposes along the flood plain of the Muddy River in the California Wash area and Lower Moapa Valley. Part of the used water percolates from septic disposal systems and artificially recharges the ground-water reservoirs. Table 8 summarizes the utilization of this imported water.

Water is imported into California Wash area, Lower Moapa Valley, and Garnet Valley, and the Black Mountains Area. A small amount of drinking water is hauled to Valley of Fire State Park in the Black Mountains Area from Lower Moapa Valley and to a mining facility at Arrolime in Garnet Valley from Las Vegas Valley. At Boulder Beach, Las Vegas Beach, Callville Bay, and Echo Bay, water from Lake Mead is pumped to recreational facilities along the shore for public supply. The net pumpage (consumption) of lake water at these sites in 1967 probably was on the order of 100 acre-feet. In addition, in 1967 about 275 acre-feet of lake water was piped to the Pabco Gypsum plant at 20/64-18b and consumed in manufacturing gypsum products.

OUTFLOW FROM THE VALLEY-FILL RESERVOIRS

The components of outflow are surface irrigation and sub-irrigation, industrial use, evaporation from surface-water bodies, streamflow, evapotranspiration of ground water, pumpage, subsurface outflow, export, and public supply use. Outflow of streams, subsurface outflow, export, and public supply has been estimated in earlier sections (tables 5, 7, 8, and p. 28).

Irrigation

Growing Season

Air temperature is a major factor in determining the length of the growing season and is of interest to farmers and ranchers. Other factors, such as wind movement, amount of daytime hours, exposure and location of field, and type of crop are important, but their consideration is beyond the scope of this report. Temperature data can be used as a rough guide in estimating the growing-season length.

Temperature data for Overton and Las Vegas Airport were used to illustrate the period between the fall and spring temperature of 28°F, a temperature at which killing frosts may occur, and are summarized in table 9. Although the periods ranged from 173 to 298 days at Overton, most years they were between 240 and 270 days. The data for Overton probably are representative of the Muddy River flood plain, the principal area of irrigation.

Water Consumption

In California Wash area and Lower Moapa Valley, the Muddy River is diverted for irrigation on its flood plain. Additional supplemental water is provided by a shallow water table that is reached by plant roots and by an irrigation well (15/66-1dd) on the Lewis Ranch. In California Wash Area, the flood plain ranges from about a quarter to three-quarters of a mile wide and has a length of about 9 miles. About a third of the flood plain is irrigated; the remainder is uncultivated and commonly covered by phreatophytes. (See "Evapotranspiration" section.) Irrigation is localized in three areas: (1) Moapa Indian Reservation, (2) Hidden Valley Ranch, and (3) Lewis Ranch.

In Lower Moapa Valley, the flood plain of the Muddy River ranges from about three-quarters to one and a quarter miles wide and is about 9 miles long. Most of the irrigated cropland is north of Overton where about three-fourths of the flood plain is irrigated. At Overton and southeast to Lake Mead, only a few small areas of cropland are irrigated. The irrigated areas are not shown on plate 1, but are limited to areas shown as younger alluvium along the Muddy River (pl. 1). Water is diverted into a complex system of ditches. Some water is temporarily stored in Bowman Reservoir, which in the fall of 1967 was being enlarged from a reported capacity of about 1,000 acre-feet to about 4,000 acre-feet. At the downstream end of the Muddy River flood plain, the State Fish and Wildlife Commission maintains the Overton Wildlife Management Area, part of which is irrigated with water from the Muddy River, from a shallow water table, and from irrigation wells. Grass is the main vegetation in irrigated areas.

In table 10, the average consumptive-use rates for irrigated crops are based on findings of Houston and Blaney (1954), U.S. Bureau of Reclamation (1962), and Houston (1950). Factors considered in assigning use rates by these workers were length of growing season, crop, geographic location, air temperature, and length of daytime hours. Because irrigation is less than optimum in the wildlife management area, the consumptive-use rate is estimated to be about 3 feet. Table 10 summarizes the water consumption by irrigation.

Water Used for Leaching Fields

Along the Muddy River, leaching of soils to keep salts moving downward below the effective root zone of the crop is a necessary irrigation practice. Leaching requires that more water be applied to fields than is necessary to grow the crop at the salt level intended. To estimate the amount of water needed for leaching, the following equation may be used (Fuller, 1965):

$$LP = \frac{ECiw}{2\ EC_e} \times 100 \qquad (1)$$

where LP is the leaching percentage; ECiw, the specific conductance of the irrigation water; and EC_e, the specific conductance of saturated-soil-paste extract associated with 50 percent decrement of crop yield. Bernstein (1964, p. 12) lists values of salt tolerance (expressed as EC_e) for several crops. A few of these crops (and their EC_e values) are listed below:

Crop	EC_e (micromhos per cm at 25°C)
Alfalfa	8,000
Beets	11,500
Bermuda grass	18,000
Cotton	16,000
Sorghum	12,000

For California Wash area, the specific conductance of irrigation water from the Muddy River may average about 1,300 micromhos. Using the EC_e value for alfalfa, the most abundant crop of the area (table 11), the computation of leaching percentage is:

$$LP = \frac{1,300 \times 100}{2 \times 8,000} = 8 \text{ percent}$$

With 60 inches of water needed to grow the crops (table 11) 65 inches have to be applied annually to the fields so that 5 inches or nearly 500 acre-feet is available for leaching.

For Lower Moapa Valley, the specific conductance of irrigation water from the river may average about 1,700 micromhos. For crops of alfalfa and grass (table 11), and using the EC_e value for alfalfa, the computation of leaching percentage is:

$$LP = \frac{1,700 \times 100}{2 \times 8,000} = 11 \text{ percent}$$

About 0.6 foot of leaching water is needed annually, or about 900 acre-feet. For the 1,500 acres of cane, sorghum, cotton, beets, and miscellaneous crops (table 11), the quantity of leaching water required annually, using EC_e of 12,000 micromhos, is about 0.25 foot, or 400 acre-feet; for the Wildlife Management Area (table 11), using EC_e of 18,000 micromhos, about 0.15 foot, or 60 acre-feet.

In summary, the annual leaching-water requirements for the irrigated land of California Wash is 500 acre-feet; for Lower Moapa Valley, nearly 1,400 acre-feet.

The leaching water is not consumed, but percolates through the soil to the water table where it migrates laterally to ditches, the Muddy River, or phreatophyte areas. Therefore, this quantity does not appear in the water budget (table 14); however, it must be available for successful farming operations.

Industrial Use

In Lower Moapa Valley, water from the Muddy River is used by Simplot Silica Products, Inc. at their two silica plants near Overton. The plant manager reports that about 160 acre-feet of water was transported by ditches to the plants in 1967 and consumed. The water was recycled through the plants many times, with a gross circulation of about 1,000 acre-feet. As described in the "Importation" section, water was imported for a gypsum plant, a power generating station, and a mining operation. Industrial use in the area totaled about 2,500 acre-feet in 1967.

Evapotranspiration of Ground Water by Nonbeneficial Phreatophytes

Ground water is discharged by evaporation from soil and transpiration by plants that root in shallow water-table areas. These plants that tap the ground-water reservoir are called phreatophytes. The phreatophytes essentially are limited to the flood plain of the Muddy River and in Las Vegas Wash. The principal types of phreatophytes are saltbush (shadscale), alfalfa, saltgrass, meadow grasses, saltcedar, mesquite, cottonwood, and tules. For the purpose of this report, they are divided into two groups: (1) beneficial phreatophytes, such as alfalfa and meadowgrass, have been described and are shown in table 10, and (2) nonbeneficial phreatophytes, such as saltbush and mesquite. Discharge by nonbeneficial phreatophytes is summarized in table 11. Rates used in table 11 are based on work done in other areas by Lee (1912), White (1932), Young and Blaney (1942), and Robinson (1958, 1965), and on rates used by Malmberg (1965) in Las Vegas Valley. Phreatophyte areas are not shown on plate 1, but along with irrigated fields, they generally are within the areas shown as younger alluvium along the Muddy River or elsewhere as indicated in table 11.

Evaporation from Surface-Water Bodies

Kohler and others (1959) estimate that the average annual lake evaporation for the area is about 80 inches, or nearly 7 feet per year. The evaporation from surface-water bodies is listed in table 12.

Lake Mead, at spillway level, has an area of 157,000 acres and at this level would lose by evaporation an average of about 1,000,000 acre-feet per year, or equal to nearly 10 percent of the average annual flow past Hoover Dam. Evaporation from Lake Mead is not included in table 12 or the water budget for the area.

Pumpage from Wells

Only a few wells are utilized as a source of water in the report area. Most are used to meet stock, public-supply, and domestic needs; in 1967 one irrigation well (15/66-1dd, table 19) on the Lewis Ranch was pumped. Its pumpage is listed in table 10. Lower Moapa Valley and Black Mountains Area probably have less than 10 active wells each, with a total estimated net pumpage of less than 100 acre-feet per year in each area. The Moapa Valley Water Company has two high-yield, public-supply wells (15/67-22bb1, 2, table 19), but because the water quality of these wells is marginal, they are used only to supplement the piped-in spring supply in emergencies. Not including the Lewis Ranch irrigation well, all the other valleys have fewer than five active wells with estimated net pumpages probably less than 10 acre-feet per year. Hidden Valley has only one stock well. In the Black Mountains Area, most of the pumpage is from a well at Overton Beach; no pumpage data were available from the National Park Service, the owners of the well. The well is used for public supply at the park and recreational facilities there.

Springs

Only a few large springs are in the report area. Data for these springs are summarized in table 13. Their flow, in general, supports small areas of phreatophytes but mostly seeps back to the water table. Their net discharge is included in nonbeneficial phreatophyte discharge estimates in table 11.

Springs at the consolidated rock-alluvium contact, such as Rogers and Blue Point Springs, probably flow to the surface because the alluvium at the contact is unable to receive and transmit the water as rapidly as the consolidated rocks can supply it. As a result, water flows to the surface at the contact and flows on the land surface to where it can be absorbed by the alluvium, usually not far downstream from where it first appears.

WATER BUDGETS

For natural conditions and over the long-term, inflow to and outflow from an area are about equal, assuming that long-term climatic conditions remain reasonably unchanged. Thus, a water budget can be used (1) to compare the estimates of inflow to and outflow from each area, (2) to determine the magnitude of imbalances in the inflow and outflow estimates, and (3) to select values that, within the limits of accuracy of this reconnaissance, hopefully represent both inflow and outflow for each area. These values in turn are utilized in a following section of the report to estimate the perennial yield or system yield of each area. Two types of budgets are presented in this report. For areas where the runoff (tables 3 and 5) is sufficient to be developed, the water budget includes both surface-water and ground-water elements (table 14). In those areas where the runoff and streamflow are minimal, only ground-water budgets are presented (table 15).

Table 15.--Preliminary ground-water budget for the valley-fill reservoir of Hidden and Garnet Valleys, Gold Butte Area, and Greasewood Basin - 1967

[All estimates in acre-feet per year]

Budget elements	Hidden Valley	Garnet Valley	Gold Butte Area	Greasewood Basin
RECHARGE:				
Recharge from precipitation (table 6)	400	400	1,000	600
Subsurface inflow (p. 23 and table 7)	0	a 400	0	0
Total (rounded)	400	800	1,000	600
DISCHARGE:				
Subsurface outflow[1] (table 7)	400	800	b 1,000	c 600
Evapotranspiration by nonbeneficial phreatophytes (table 11)	0	0	small	small
Pumpage from wells (p. 36)	small	small	small	small
Total (rounded)	400	800	1,000	600
VALUE SELECTED TO REPRESENT BOTH RECHARGE AND DISCHARGE	400	800	1,000	600

1. Assumed equal to ground-water recharge (tables 6 and 7).
a. From Hidden Valley.
b. Discharge to Lake Mead.
c. Flows across State line to Arizona.

Table 16.--Partial and detailed chemical analyses of water from wells, springs, seeps, and streams

[Field-office and detailed laboratory analyses by the U.S. Geological Survey, except as indicated]

Location	Source	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)[4]	Sulfate (SO_4)	Chloride (Cl)	Dissolved-solids content[5]	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium-adsorption ratio (SAR)	Sodium hazard
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]										Factors affecting suitability for irrigation[2]		
GROUND WATER																	
Black Mountains Area																	
17/68-23ab[6]	Well	1-31-66	--	--	405 20.21	216 17.79	(6)	296 4.85	2,060 42.89	516 14.56	4,020	1,900 38.00	5,020	7.1	Very high	5.5	Medium
18/67-12dd[6]	Rogers Spring	1-31-66	--	--	443 22.11	140 11.49	(6)	166 2.72	1,680 34.98	334 9.42	3,020	1,680 33.60	3,750	7.3	do.	3.1	Low
18/68-7ab[7]	Blue Point Spring	11-27-45	--	--	472 24.05	167 13.93	317 13.78	122 2.00	1,910 36.67	355 10.01	e 3,300	1,900 37.98	--	--	do.	3.2	Medium
19/67-16bb	Bitter Spring	11-13-67	64	18	601 29.99	189 15.56	251 10.92	141 2.31	2,360 49.13	178 5.02	e 3,670	2,280 45.55	4,100	7.6	do.	2.3	Low
21/65-9db[6]	Well	10-12-67	84	29	298 14.87	113 9.33	828 36.04	98 1.61	1,200 24.98	1,190 33.57	3,720	1,210 24.20	5,700	7.0	do.	10	High
California Wash																	
14/66-31c[7]	Well	Late 1946	--	--	55 2.74	18 1.48	261 11.32	371 6.08	285 5.93	125 3.53	940	211 4.22	--	--	High	7.8	Medium
15/66-1dc[7]	Well	1-22-40	--	--	474 23.65	164 13.47	153 6.65	183 3.00	1,750 36.37	156 4.40	2,800	1,860 37.12	4,100	--	Very high	1.6	Low
-2b[6]	Seep	10-13-49	--	--	74 3.69	38 3.13	138 6.01	311 5.10	254 5.29	85 2.40	780	340 6.82	1,210	--	High	3.2	Do.
-4c[6]	Seep	10-13-49	66	19	85 4.24	55 4.52	174 7.57	354 5.80	355 7.39	110 3.10	995	438 8.76	1,550	--	do.	3.6	Do.
-4d[6]	Seep	10-13-49	--	--	66 3.29	38 3.13	141 6.13	302 4.95	251 5.23	82 2.31	768	320 6.42	1,190	--	do.	3.4	Do.
-5d[6]	Seep	10-13-49	--	--	109 5.44	80 6.58	256 11.11	332 5.44	529 11.01	180 5.08	1,430	601 12.02	2,110	--	do.	4.5	Medium
Garnet Valley																	
17/64-21cb1	Well	9-24-12	--	--	116 5.79	50 4.11	100 4.36	178 2.92	335 6.97	155 4.37	870	495 9.90	870	--	do.	2.0	Low
-21cb2	Well	11- 9-67	--	--	118 5.89	57 4.70	145 6.30	215 3.52	405 8.43	175 4.94	e 1,050	530 10.59	1,600	7.6	do.	2.7	Do.
Greasewood Basin																	
16/71-22cc	Spring	11-11-67	63	17	54 2.69	31 2.54	4 .17	303 4.97	10 .20	8 .23	e 290	262 5.23	490	7.6	Medium	.1	Do.
Lower Moapa Valley																	
15/67-22bb[6] [8]	Well	7- -67	68	20	184 9.18	80 6.58	(6)	355 5.82	771 16.05	174 4.91	1,690	789 15.76	--	7.6	Very high	3.8	Do.
-27ba[6]	Seep	10-12-49	--	--	272 13.57	180 14.81	325 14.13	408 6.69	1,300 27.07	235 6.63	2,640	1,420 28.38	3,460	--	do.	3.8	Medium
-34ab[6]	Well	10-11-49	76	24	106 5.29	54 4.44	177 7.73	371 6.08	421 8.77	92 2.60	1,070	486 9.73	1,610	--	High	3.5	Low
16/67-1bc[6]	Seep	10-12-49	67	19	196 9.78	139 11.43	409 17.79	446 7.31	1,230 25.61	215 6.06	2,470	1,060 21.21	3,320	--	Very high	5.5	Medium
-1bc	Well	11-10-67	--	--	85 4.24	73 6.01	188 8.18	309 5.06	462 9.62	133 3.75	e 1,050	513 10.25	1,700	7.7	High	3.6	Low
-1cc	Well	10-11-49	67	19	161 8.03	88 7.24	231 10.06	554 9.08	552 11.48	168 4.74	e 1,530	764 15.27	2,200	--	do.	3.6	Do.
-1dc[6]	Seep	10-12-49	70	21	153 7.63	104 8.56	256 11.14	338 5.54	805 16.76	175 4.94	1,720	809 16.19	2,420	--	Very high	3.9	Medium
-11dd[6]	Well	10-12-49	--	--	148 7.39	103 8.47	408 17.73	260 4.26	998 20.78	205 5.78	2,130	793 15.86	2,900	--	do.	6.3	Do.
16/68-7cb	Well	11-10-67	68	20	187 9.33	132 10.85	478 20.80	496 8.13	1,150 23.94	316 8.91	e 2,560	1,010 20.18	3,400	7.7	do.	6.5	Do.
-7cb[6]	Seep	10-11-49	62	17	164 8.18	132 10.86	326 14.20	398 6.52	984 20.49	220 6.21	2,090	952 19.04	2,910	--	do.	4.6	Do.
-20bd[6]	Angel Spring	1-31-66	--	--	146 7.29	102 8.41	(6)	251 4.11	834 17.36	186 5.25	1,740	785 15.70	2,430	7.4	do.	4.1	Do.
-30ba	Well	11-10-67	68	20	422 21.06	133 10.91	336 14.63	281 4.61	1,670 34.77	256 7.22	e 3,000	1,600 31.97	3,700	7.6	do.	3.7	Do.
Muddy River Springs Area																	
14/65-21aa[6]	Muddy River Springs	9-12-63	89	32	70 3.49	26 2.11	(6)	274 4.49	179 3.73	64 1.81	620	280 5.60	964	7.5	High	2.6	Low
SURFACE WATER																	
14/65-15d[6]	Muddy River[9]	3- 9-62	71	22	71 3.54	33 2.72	(6)	303 4.97	216 4.50	75 2.12	719	313 6.26	1,090	--	do.	3.1	Do.
15/67-21ab	Do.	11-10-67	66	19	119 5.94	43 3.51	146 6.33	313 5.13	373 7.77	102 2.88	e 970	473 9.45	1,500	--	do.	2.9	Do.
16/67-12db	Do.	11-10-67	68	20	151 7.53	65 5.38	221 9.59	362 5.93	590 12.28	152 4.29	e 1,390	646 12.91	2,000	--	do.	3.8	Do.
21/63-14da[6] [10]	Las Vegas Wash	Lowest[11]	--	--	408 20.36	192 15.79	(6)	265 4.34	1,520 31.65	876 24.71	3,980	1,820 36.36	5,090	7.3	Very high	5.3	Medium
		Highest[11]	--	--	672 33.53	306 27.17	(6)	335 5.49	2,180 45.39	1,620 45.70	6,290	2,940 58.70	7,640	8.2	do.	6.6	High
17/68-23[6]	Lake Mead	1-31-66	--	--	88 4.39	26 2.17	(6)	153 2.51	282 5.87	88 2.48	676	328 6.56	1,060	8.0	High	2.3	Low
22/64-14[6]	Do.	2-21-66	--	--	94 4.69	31 2.51	(6)	151 2.47	326 6.79	104 2.93	760	360 7.20	1,180	8.2	do.	2.6	Do.

1. Milligrams per liter and milliequivalents per liter are metric units of measure that are virtually identical to parts per million and equivalents per million, respectively, for all waters having a specific conductance less than about 10,000 micromhos. The metric system of measurement is receiving increased use throughout the United States because of its value as an international form of scientific communication. Therefore, the U.S. Geological Survey recently has adopted the system for reporting all water-quality data. Where only one number is shown, it is milligrams per liter.

2. Salinity hazard is based on specific conductance (in micromhos) as follows: low, 0-250; medium, 251-750; high, 751-2,250; very high >2,250. Sodium adsorption ratio (SAR) provides an indication of what effect an irrigation water will have on soil-drainage characteristics. SAR is calculated as follows, using milliequivalents per liter: $SAR = Na/\sqrt{(Ca + Mg)/2}$. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio. Residual sodium carbonate (expressed in milliequivalents per liter) is tentatively related to suitability for irrigation as follows: safe, 0-1.25; marginal, 1.26-2.50; unsuitable, >2.50. RSC is 0.00 (safe) for all analyses listed above except well water 14/66-31c, which has a value of 1.86 (marginal).

The several factors should be used as general indicators only, because the suitability of a water for irrigation also depends on climate, type of soil, drainage characteristics, plant type, and amount of water applied. These and other aspects of water quality for irrigation are discussed by the U.S. Salinity Laboratory Staff (1954).

3. Computed as the milliequivalent-per-liter difference between the determined negative and positive ions; expressed as sodium (the concentration of sodium generally is at least 10 times that of potassium). Computation assumes that concentrations of undetermined negative ions--especially nitrate--are small.
4. All carbonate (CO_3) values 0 mg/l except: 15/66-5d, 47 mg/l (1.57 me/l); 15/67-27ba, 61 mg/l (2.03 me/l); 16/67-11dd, 83 mg/l (2.77 me/l).
5. Computed sum, with bicarbonate expressed as carbonate. Letter "e" denotes estimated sum. For Las Vegas Wash only, values represent residue on evaporation, rather than computed sum.
6. Detailed laboratory analysis; additional determinations are listed on next page.
7. Analysis by State of Nevada.
8. Analysis by Desert Research Institute.
9. Muddy River analyses are listed in downstream order.
10. Analyses by Federal Water Pollution Control Administration.
11. Lowest and highest values from analyses of 54 samples collected between September 26, 1966 and October 10, 1967.

Suitability for Domestic Use

The U.S. Public Health Service (1962, p. 7-8) has formulated drinking-water standards that are generally accepted as a guideline for public supplies. The standards, as they apply to data listed in table 16, are as follows:

Constituent	Recommended maximum concentration (milligrams per liter)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a About 0.8
Nitrate (NO_3)	45
Total dissolved solids	500

a. The optimum concentration is about 0.7 mg/l. Water containing more than about 1.4 mg/l should not be consumed regularly, especially by children.

Most of these are only recommended limits, and water therefore may be acceptable to many users despite concentrations exceeding the given values.

Among the listed constituents, excessive iron causes staining of porcelain fixtures and clothes, whereas large amounts of chloride and dissolved solids impart an unpleasant taste, and sulfate can have a laxative effect on persons who are drinking a water for the first time. Excessive fluoride tends to stain teeth, especially of children, and large amounts of nitrate are dangerous for infants and pregnant women because of the possibility of "blue-baby" disease.

The hardness of a water is important to many domestic users. Therefore, the U.S. Geological Survey has adapted the following rating:

Suitability for Agricultural Use

In evaluating the desirability of a water for irrigation, the most critical factors include dissolved-solids concentration, the relative proportion of sodium to calcium plus magnesium, and the abundance of constituents such as boron that can be toxic to plants. Four factors used by the U.S. Salinity Laboratory (1954, p. 69-82) to evaluate the suitability of irrigation water are listed in table 16, and are discussed briefly in footnote 2 of that table. Boron, though essential to plant nutrition in minor amounts, is highly toxic to some plants when it exceeds certain limits. The recommended limits for boron in water irrigating sensitive, semitolerant, and tolerant crops are about 1, 2, and 3 mg/l, respectively, according to Scofield (1936).

Muddy River, which presently supplies almost all irrigation water in the study area, has proved acceptable chemically where used along its flood plain. Because of its high salinity hazard, the water must be applied carefully, and only in areas of adequate soil drainage, to prevent salt buildup. These potential problems of high salinity are eased somewhat, however, by the river's low sodium hazard throughout most of the year. Boron apparently is not a problem.

Most ground water beneath the Muddy River flood plain is less desirable for irrigation than river water, because of characteristically higher salinity and sodium hazard. In other areas the suitability of ground water for irrigation is uncertain. Analyses of two well waters in 17/64-21cb suggest that water throughout large parts of areas such as California Wash area, Garnet Valley, and Hidden Valley may be generally suitable, but deep.

The water of Lake Mead, though high in salinity hazard, is otherwise suitable for irrigation.

Most animals are more tolerant of poor water than man. Although available data are somewhat conflicting, dissolved-solids contents below 4,000-7,000 mg/l apparently are safe and acceptable (McKee and Wolf, 1963, p. 112-113). Thus, all sampled water within the study area is sufficiently dilute for livestock.

Table 17.--Yield and water consumption from the hydrologic system

[All quantities rounded]

Hydrographic area	Estimated system yield (acre-feet per year)	Estimated perennial yield (acre-feet)	Estimated water consumption from system in 1967 (acre-feet)
Hidden Valley	--	200	a <10
Garnet Valley	--	400	a 10
California Wash area	40,000 (California Wash area and Lower Moapa Valley combined)	--	22,000
Lower Moapa Valley			
Black Mountains Area	b 7,000	--	500
Gold Butte Area	--	500	a <10
Greasewood Basin	--	300	a <10

a. From ground-water system only.

b. Not of suitable chemical quality for some uses.

Table 18.--Estimated stored water in the upper 100 feet of saturated valley fill

Hydrographic area	Estimated area having 100 feet or more of saturated thickness[1] (acres)	Estimated stored water[2] (acre-feet)
Hidden Valley	15,000	150,000
Garnet Valley	50,000	500,000
California Wash area	100,000	1,000,000
Lower Moapa Valley	80,000	800,000
Black Mountains Area	150,000	1,500,000
Gold Butte Area	100,000	1,000,000
Greasewood Basin	20,000	200,000

1. Rounded.
2. Based on an assumed specific yield of 10 percent. May include a large percent of poor-quality water.

FUTURE SUPPLY

The largest future supply of water is in the combined California Wash-Lower Moapa Valley area. The unused part of the system yield, most of which is evapotranspiration losses by nonbeneficial phreatophytes and Muddy River, flows to Lake Mead. Ultimately, most of this water is from the Muddy River. Because of the enlargement of Bowman Reservoir, most of the salvable surface-water outflow to Lake Mead (an estimated 5,000 acre-feet per year) could now be salvaged during the winter, the period of principal loss. The salvage of principal losses by pumping irrigation wells, that is, surface-water and ground-water outflow and nonbeneficial phyreatophyte discharge, is impractical under the present water-quality requirements. Ground water in the discharge areas generally is not suitable for irrigation. However, phreatophyte losses (about 13,000 acre-feet per year) could be partly salvaged by denying them a plentiful supply of water by lining more ditches, reservoirs, and the Muddy River channel with an impermeable material and by using more efficient irrigation practices, such as applying water to fields with sprinklers rather than with ditches. These more efficient water-use practices, however, may not be feasible under present economic conditions.

For Hidden and Garnet Valleys, Gold Butte Area, and Greasewood Basin, the only dependable source of water is the ground-water reservoir or springs. Salvage of ground-water outflow is possible if wells are near the discharge areas, but in salvaging ground-water outflow, ground water in storage probably would continue to be pumped for a prolonged period of time as part of the well discharge. The best areas to salvage ground-water outflow are in Hidden and Garnet Valleys, along the southeastern and eastern sides of the valley-fill reservoir; in the Gold Butte Area and Greasewood Basin, along the alluvial slopes between recharge and discharge areas.

The flow from springs issuing from consolidated rocks in the Black Mountains and Gold Butte Areas and Greasewood Basin can be diverted and consumed. This would deprive the valley-fill reservoir of some recharge and have much the same effect as salvaging water from the reservoir. Most of the larger springs in these areas are not potable, but some small, potable springs (table 13) probably could be developed to supply the needs of campers and tourists in recreation areas. A comprehensive inventory of springs and their hydrologic settings was not made, but it could be accomplished by a hydrologist in a few weeks of field work, including collection of water samples for chemical and bacterial analyses.

NUMBERING SYSTEM FOR HYDROLOGIC SITES

The numbering system for hydrologic sites in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. This location number consists of three units: the first is the township south of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by letters that indicate the quarter section and quarter-quarter section, the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 15/65-1dd (table 19) is the well recorded in the SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 1, T. 15 S., R. 65 E., Mount Diablo base line and meridian. For sites that cannot be located accurately to the quarter-quarter section, only that part of the location number is given that represents the ability to determine the location of the site.

Because of limitation of space, wells and springs are identified on plate 1 only by section number and quarter-quarter section letters. Township and range numbers are shown along the margins of the area on plate 1 and apply only to Nevada.

Table 19.--Data of selected wells

Owner or name: BLM, Bureau of Land Management;
NPS, National Park Service

Use: C. construction, D, domestic; E, exploration;
I, irrigation; Ind, industrial; O, oil test;
PS, public supply; RR, railroad; S, stock;
U, unused

Water-level measurement: M, measured; R, reported

Log number: Log number in the files of the State Engineer

Location number	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land surface altitude (feet)	Water-level measurement Depth (feet)	M or R	Date	Chief aquifer (depth in feet)	Log number	Remarks
							GARNET VALLEY						
17/63-14dd	U.S.G.S. Dry Lake No. 2	1966	970	--	E	--	2,070	--	-	--	-	--	From Jenkins (1966).
17/64-19bd	U.S.G.S. Dry Lake No. 1	1966	1,500	—	E	—	1,967	--	-	--	--	--	Do.
17/64-21c1	Wells-Stewart Construction Co.	1958	575	8	C,U	--	2,060	260	R	1958	532-75	--	West of RR. First water at 532 f
17/64-21c2	do.	1958	550	8	C,U	--	2,060	272	R	1958	297-550	4105	East of RR. First water at 297 f
17/64-21cb1	Union Pacific Railroad Co. well 1	Pre-1912	461	--	U	--	2,100	284	R	1912	--	--	
17/64-21cb2	do. well 2	--	576	16	RR	30/13	2,080	264	R	1967	--	--	100 ft. west of tracks.
17/64-26	Jack Pelhem	1951	582	10	S,D	150/--	2,230	160	R	1951	530-583	1769	Water smells bad. First water at 140 ft.
18/64-7bb1	Martin and son oil well	1955	793	16	O	--	2,045	226.40	M	11-29-56	235-264	--	500 ft. east of old highway and 500 feet north of road to Garne
18/64-7bb2	Vinnell Corporation	1963	600	12	C,U	100/--	2,060	235.75	M	11- 9-67	389-505	--	
							CALIFORNIA WASH						
14/66-35d	--	1947	118	16	I	1,400/60	1,490	20	M		62-88	243	
15/66-1dc	R. A. West	--	325	7	S	10/--	1,500	--	-	--	257-325	--	
15/66-1dd	Paul Lewis	1960	170	14,12	I	830/69	1,640	12	R	1960	75-89	5290	Cold water
15/66-2bb	Jay Robb	1947	114	16	I	100/--	1,550	12	R	1947	60-66	286	Cold water
15/66-4aa	Hidden Valley Ranch	1950	178	20	I,U	200/--	1,580	0	R	1950	0-33	1720	75°F. Drilled in spring.
15/66-6	Hidden Valley Ranch, No. 2	1950	100	12	I,U	400/--	--	1	R	1950	--	1461	¼ mile NW of dairy barn, 250 ft. W of flowing well.
16/65-10cd	BLM	--	--	6	S	--	--	--	-	--	--	--	
16/65-33aa	BLM, Marshall well 16	1949	400	6	S,U	12/--	1,970	325.90	M	11-12-67	372-380	826	First water at 350 ft. Salt water
17/65-31db	BLM	1949	258	8	S	--	2,275	238	R	1949	238-245	790	Slightly salty water.
18/64-25aa1	BLM, Muddy Mountain well	1948	--	8	S,U	--	--	--	-	--	--	--	
18/64-25aa2	Apex Oil well	1949	1,025	16	O	--	2,590	945	R	1949	945-950	1012	Salt water
18/65-18cc	BLM	1949	860	--	S	--	2,590	825	R	1949	845-851	939	Windmill
							LOWER MOAPA VALLEY						
15/67-22aa	F. H. Langford	1958	112	8	S	--	1,430	5.5	R	1958	19-30	4224	
15/67-22b	Louis Adams	1957	120	6	D,U	--	1,400	21	R	1957	102-107	3943	
15/67-22bb1	Moapa Valley Water Co. No. 1	1967	154	16	PS	3,250/31	1,410	22	R	1967	152-154	9714	68°F. First water at 60 ft. Chie aquifer is limestone.
15/67-22bb2	Moapa Valley Water Co. No. 2	1967	163	16	PS	2,500/104	1,410	22	R	1967	60-154	9716	68°F
15/67-26cb	Logandale Cemetary	1957	100	6	I	--	1,370	22	R	1957	30-50	3944	
15/67-34ab	W. Whipple	--	87	8	U	--	1,360	8.49	M	5-10-50	77-87	--	
16/67-1b	Paul Lewis	--	97	6	S	--	--	7.82	M	5-11-50	--	--	
16/67-1bc	--	--	--	6	D	--	--	8.50	M	11-10-67	--	--	
16/67-24bd	M. B. Metcalf	1966	140	16,8	I	1,100/--	1,250	6	R	1966	95-140	9392	Cool water
16/68-7cb	J. G. Perkins	--	80	6	D	--	--	20	R	--	80	--	Drilled to 500 ft. deep.
								13.92	M	11-10-67			
16/68-30ad	Simplot Silica Products, Ind.	1948	75	12	Ind	--	1,230	23	R	1948	52-73	379	Cool water
16/68-30ba	do.	--	98	--	Ind	--	1,230	--	-	--	--	--	
							BLACK MOUNTAINS AREA						
17/67-26b	Valley of Fire State Park	1965	100	6	PS,U	20/--	1,880	33.25	R	1965	--	8325	First water at 55 ft.
17/68-23ab	NPS, Overton Beach well	1964	175	5	PS	80/--	--	97.5	R	1964	132-143	--	Cool water. Used at landing.
19/68-6	NPS, Echo Bay No. 1	1956	300	14,10	PS,U	--	1,300	83	R	1956	93-116	3509	Salt water
19/68-6	NPS, Echo Bay No. 2	1956	175	10	PS,U	--	1,300	125	R	1956	125-136	3510	Salt water
20/63-1db	Fibreboard Paper Products Corp. well No. 9	1958	240	10	Ind	8/--	1,960	40	R	1958	46-50	4401	First water at 46 ft.
20/64-18cb	Fibreboard Paper Products Corp. well No. 5	1958	130	12	Ind	1/--	1,770	20	R	1958	35-45	4402	First water at 35 ft.
20/65-7bd	Rosen Oil, No. 1 Muddy Dome	1965	5,666	10	O	--	2,305	--	-	--	--	--	
21/64-21cc	Wells-Stewart Construction Co.	1958	550	10,8	C,U	--	1,550	272	R	1958	297-550	5607	
21/65-9db	NPS, Callville Bay campground	1967	200	--	PS,U	30/--	1,300	105	M	10-12-67	--	--	Salt water
22/64-14cc	NPS, Boulder Beach well	1955	200	8	PS,U	--	1,300	135	R	1955	143-200	3018	Salt water
							GOLD BUTTE AREA						
17/70-25cd	Dan Mason	1953	802	6	S	--	2,380	--	-	--	--	2435	Salt water
19/70-17ad	--	--	--	12	D,U	--	3,800	35.15	M	11-11-67	--	--	
20/70-2dd	Blue Bird Mine Co.	1956	152	10,6	Ind	--	3,620	109	R	1956	109-115	4819	

Table 20.--Continued

Material	Thick-ness (feet)	Depth (feet)
17/68-23ab		
Sand and gravel	105	105
Clay, sand, and gravel, water-bearing	5	110
Sand and gravel, water-bearing	33	143
Sandstone	13	156
Sand and gravel	14	170
Clay and sand	12	182
17/70-25cd		
Sand and gravel	6	6
Shale, red	465	471
Shale, blue and brown	123	594
Lime, hard and soft	208	802
18/64-7bb		
Clay and gravel	55	55
Clay	90	145
Clay and gravel	118	263
Clay, streaks of limestone	67	330
Clay and gravel	15	345
Gravel, cemented	18	363
Clay, sandy	12	375
Limestone	2	377
Clay, sandy	12	389
*Gravel, cemented	116	505
Clay, red	20	525
Clay, gray	5	530
Clay, blue	70	600

Material	Thick-ness (feet)	Depth (feet)
18/65-18cc		
Gravel, cemented	90	90
Clay, blue	10	100
Gravel and sandstone	155	255
Clay, blue and yellow	250	505
Gravel, cemented	55	560
Clay, red	110	670
Gravel, cemented	65	735
Clay, sand, and rock	70	805
Lime, gray	15	820
Sand, water-bearing	15	835
Limestone, black	10	845
Sand, water-bearing	6	851
Lime	9	860
19/68-6		
*Sand and gravel	131	131
Clay, gray	8	139
Sand and gravel	3	142
Clay, white and red	113	255
Salt	10	265
Clay, red, sandy, and salt	35	300
21/64-21cc		
Gravel, cemented	8	8
Clay, yellow, blue, and red	264	272
Limestone	25	297
*Sandstone	28	325
*Limestone, broken	225	550

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Report No.	Valley
45	Clayton Valley Alkali Spring Valley Lida Valley Stonewall Flat Oriental Wash Grapevine Canyon
46	Mesquite Valley Ivanpah Valley Jean Lake Valley Hidden Valley
47	Thousand Springs Valley
48	Snake River Basin
49	Butte Valley

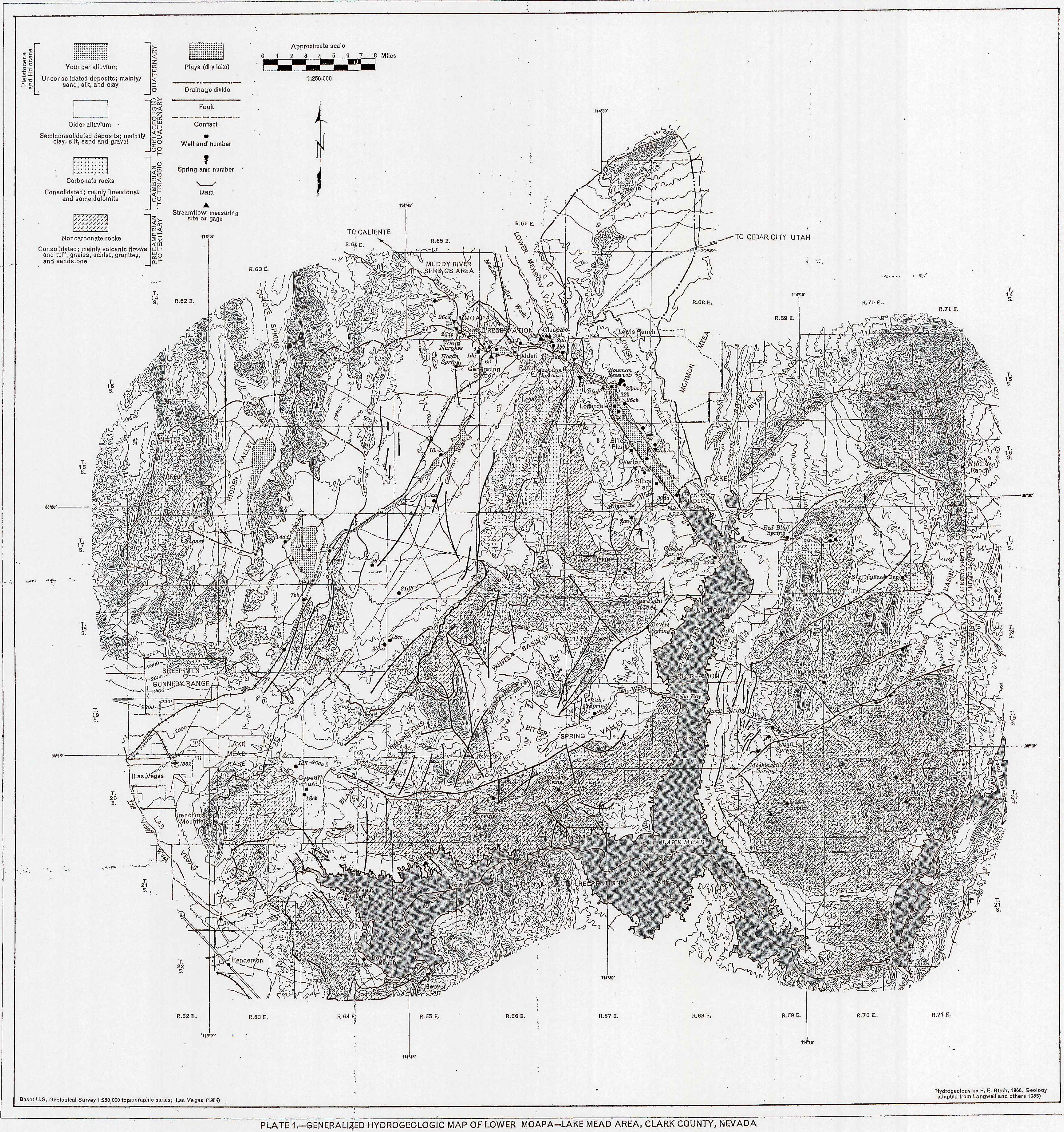

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF LOWER MOAPA—LAKE MEAD AREA, CLARK COUNTY, NEVADA